INTEGRATING PEST BIOLOGY, CROP PHENOLOGY AND INSECTICIDE USE TO MANAGE ARTHROPODS ATTACKING VEGETABLE CROPS

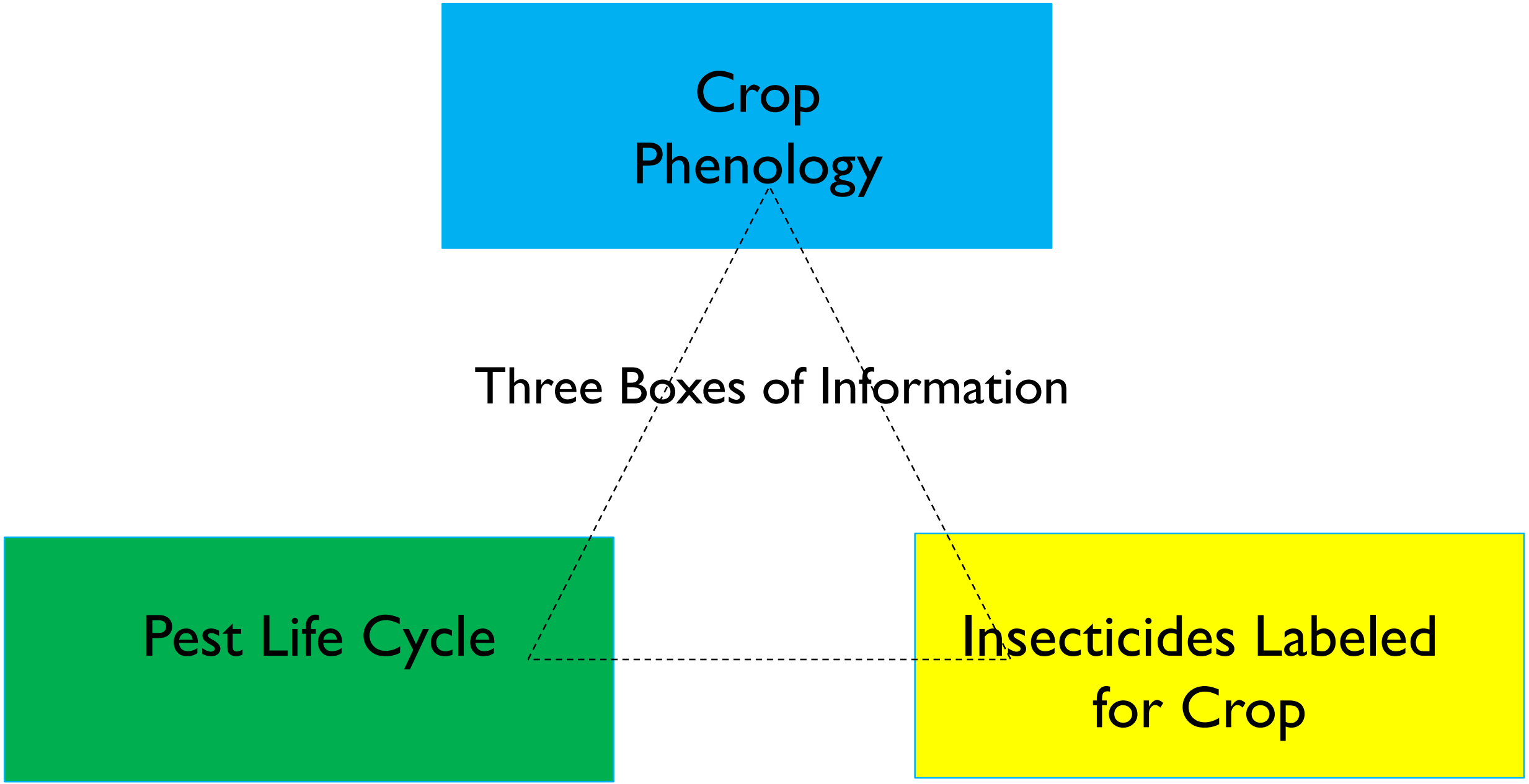
Dr. Hugh Smith

Vegetable Entomologist

Gulf Coast Research and Education Center

Balm, FL 33598

Graphics: Courtney Sherman

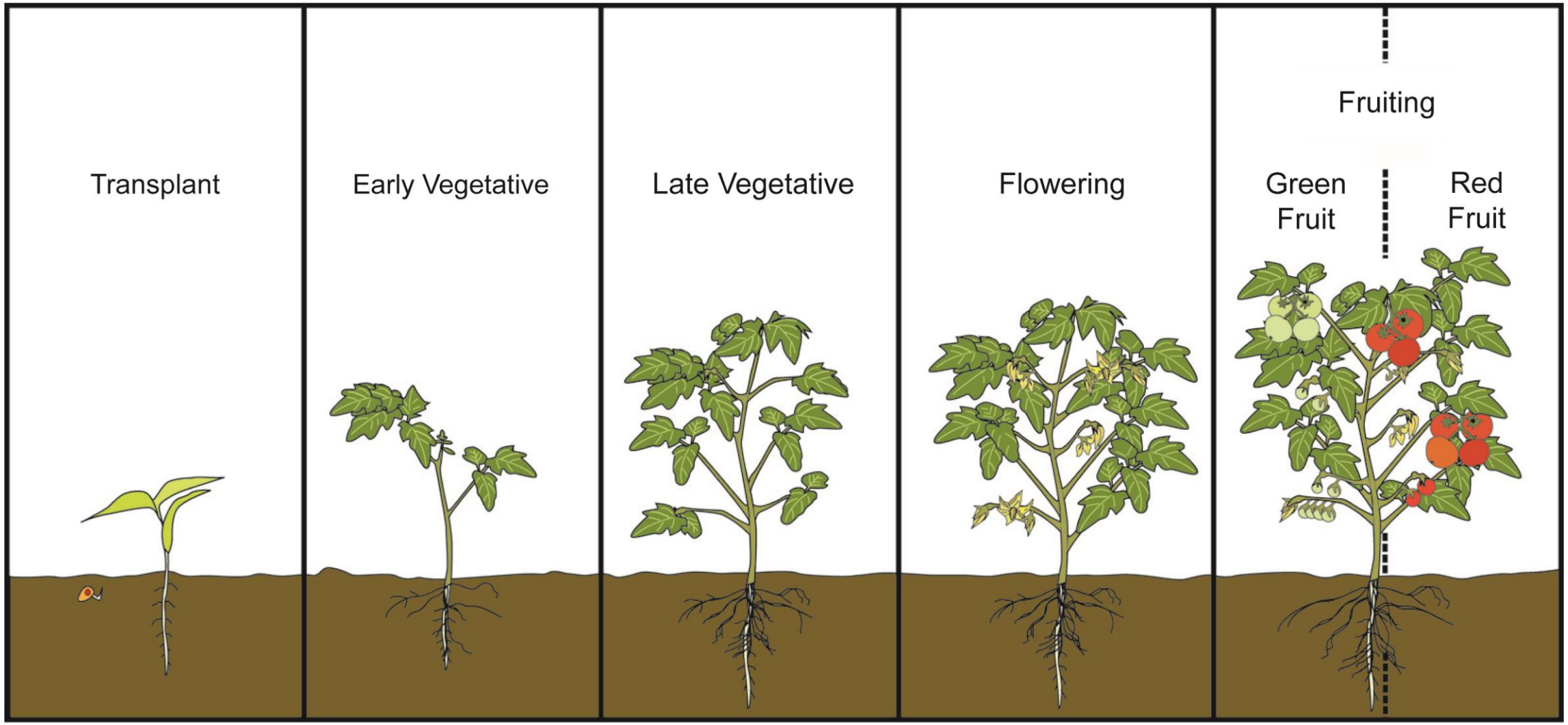

Crop
Phenology
Three Boxes of Information
Pest Life Cycle
Insecticides Labeled
for Crop

Crop Phenology:
The sequence of life cycle events: transplant, early vegetative, late vegetative, flowering, fruiting

Insect Life Cycle:
The sequence of each life stage:
Egg, larva, pupa, adult (complete metamorphosis)
Egg, nymph, adult (incomplete metamorphosis)

Insecticides Labeled for Crop:
It is illegal to apply an insecticide to a crop for which it is not legally registered. Check www.cdms.net for labels.

Tomato Phenology



In 2015, the EPA initiated extensive pollinator safety language in labels.

PROTECTION OF POLLINATORS

APPLICATION RESTRICTIONS EXIST FOR THIS PRODUCT BECAUSE OF RISK TO BEES AND OTHER INSECT POLLINATORS. FOLLOW APPLICATION RESTRICTIONS FOUND IN THE DIRECTIONS FOR USE TO PROTECT POLLINATORS.

Look for the bee hazard icon in the Directions for Use for each application site for specific use restrictions and instructions to protect bees and other insect pollinators.

This product can kill bees and other insect pollinators.

Bees and other insect pollinators will forage on plants when they flower, shed pollen, or produce nectar.

Bees and other insect pollinators can be exposed to this pesticide from:

- Direct contact during foliar applications, or contact with residues on plant surfaces after foliar applications
- Ingestion of residues in nectar and pollen resulting from foliar applications.

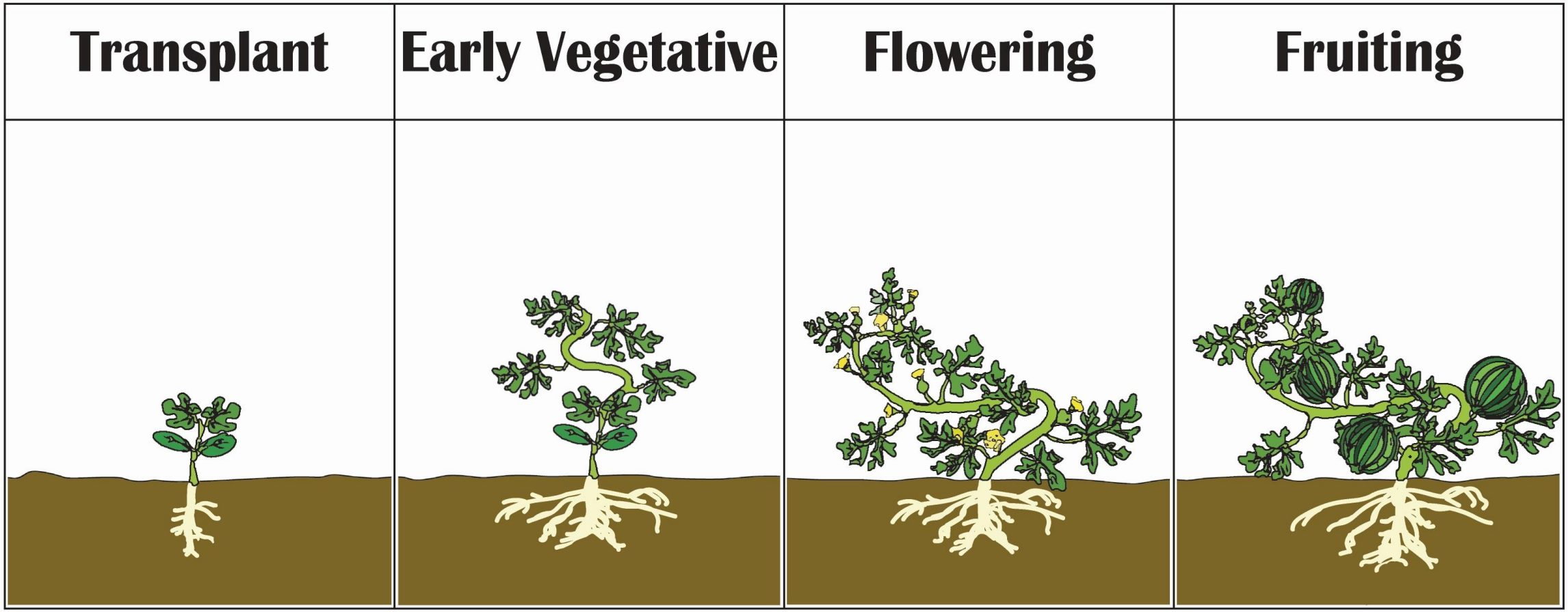
When Using This Product Take Steps To:

- Minimize exposure of this product to bees and other insect pollinators when they are foraging on pollinator attractive plants in and around the application site.
- Minimize drift of this product on to beehives or to off-site pollinator attractive habitat. Drift of this product onto beehives or off-site to pollinator attractive habitat can result in bee kills.

Information on protecting bees and other insect pollinators may be found at the Pesticide Environmental Stewardship website at: http://pesticidestewardship.org/PollinatorProtection/Pages/default.aspx.

Pesticide incidents (for example, bee kills) should immediately be reported to the state/tribal lead agency. For contact information for your state, go to: www.aapco.org/officials.html. Pesticide incidents should also be reported to the National Pesticide Information Center at: www.npic.orst.edu or directly to EPA at: beekill@epa.gov

Watermelon Phenology



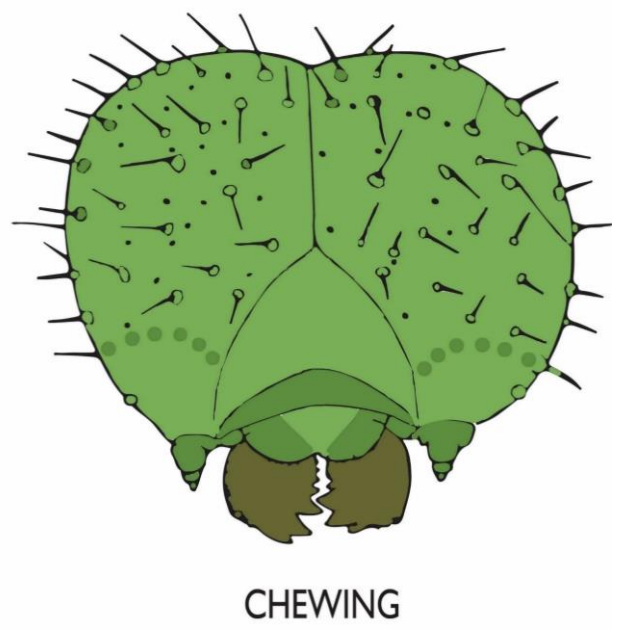
II. Pest Biology

1. Life Cycle (days)

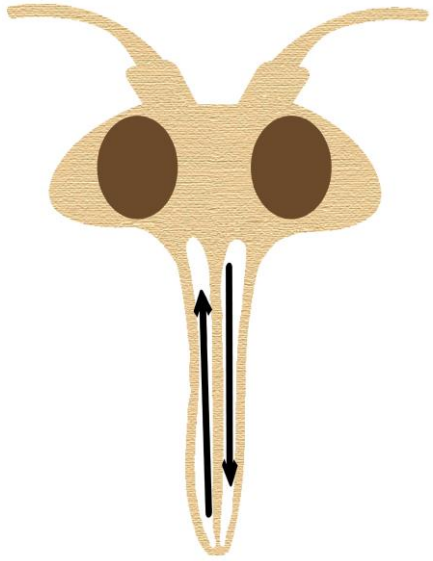
2. Does it transmit a pathogen or is damage mechanical?

   (feeding, ovipositing, mining, boring…)

3. What sort of mouth does it have?



CHEWING

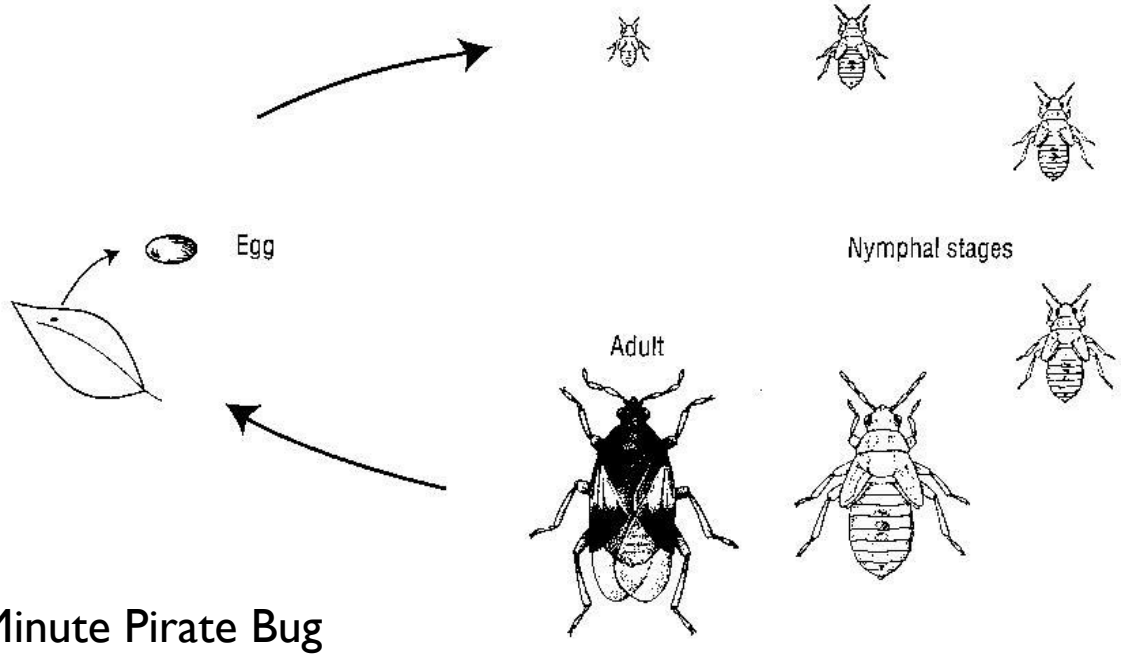


PIERCING-SUCKING

II. Pest

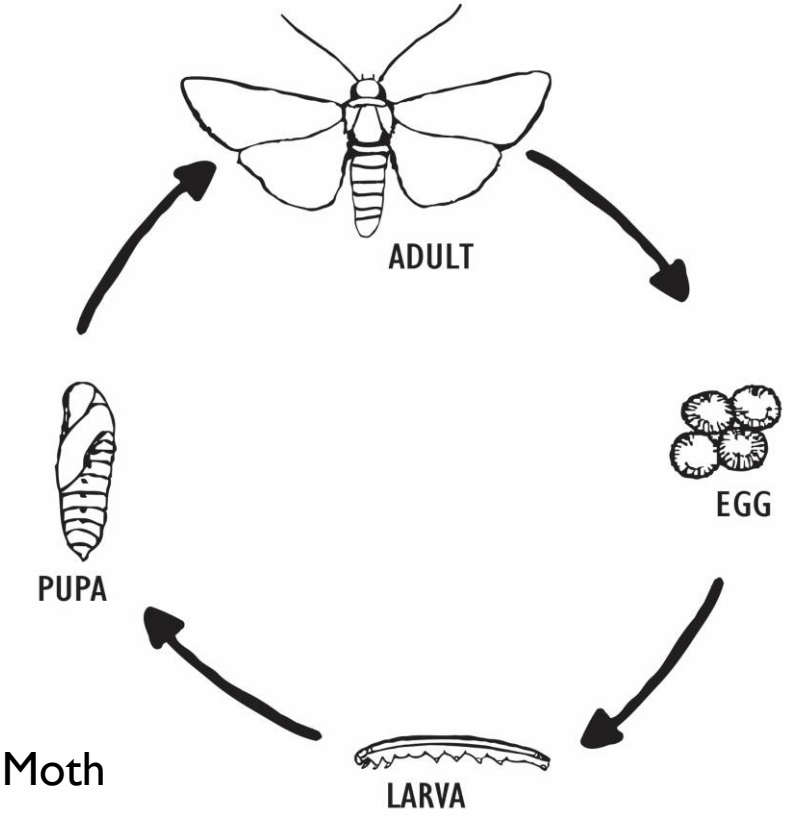
1. Life Cycle
2. Damage
3. Mouth type
4. Metamorphosis

Incomplete Metamorphosis



Minute Pirate Bug

Complete Metamorphosis



Moth

Host Range

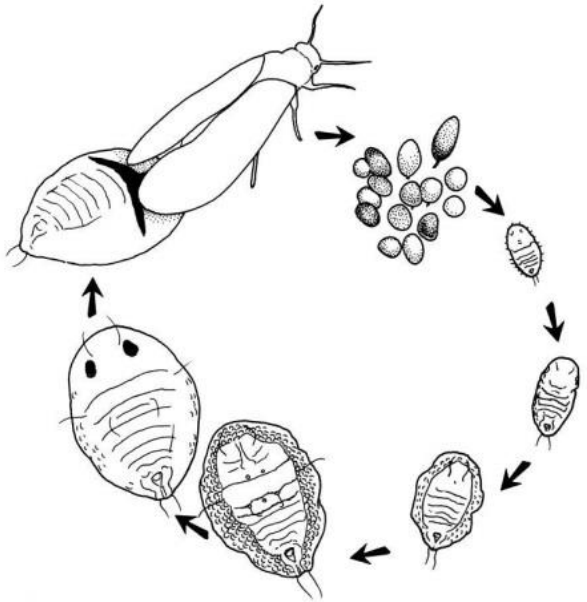
Almolonga, Guatemala. 1989.

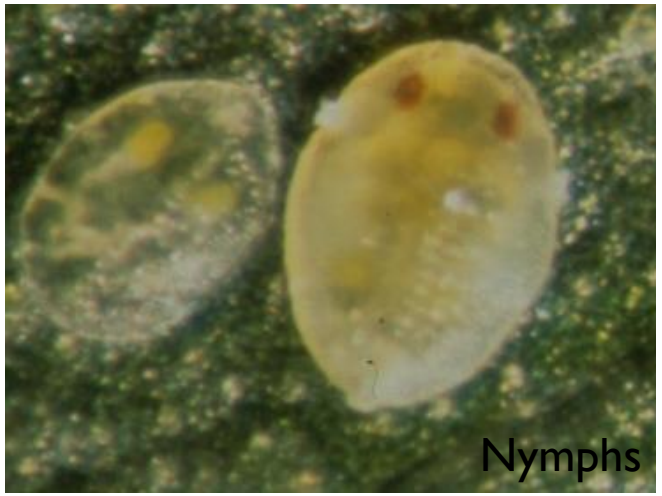
Host Range
Sweetpotato whitefly vs Diamondback moth

Broad host range

Just eats Brassicas

Sweetpotato whitefly, *Bemisia tabaci* biotype B (MEAM1)

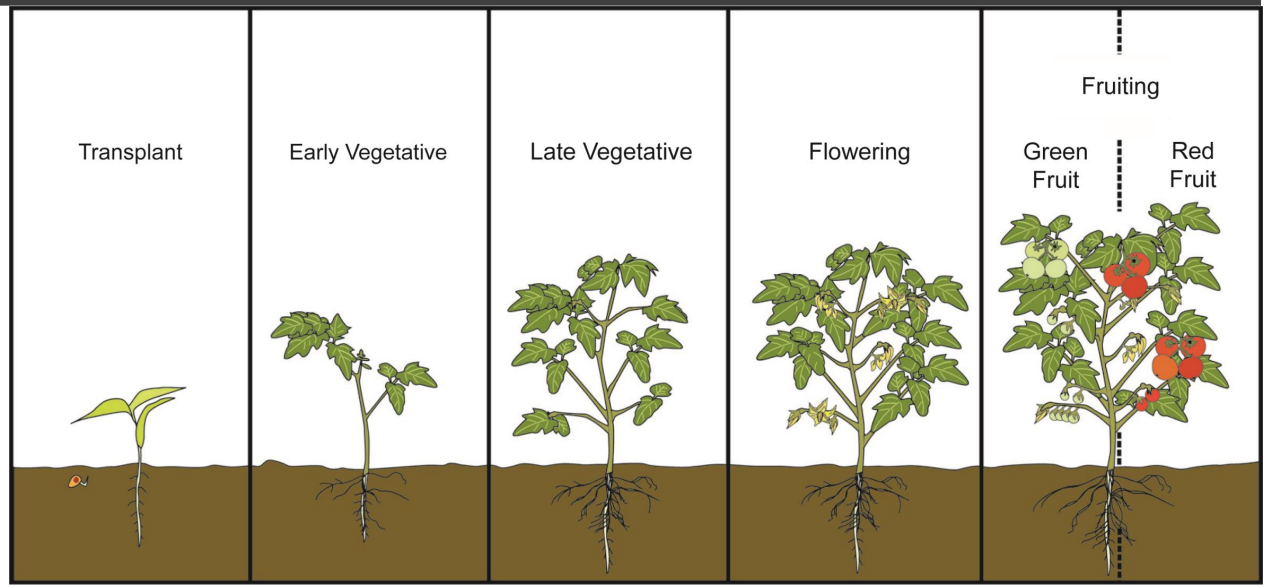




Life cycle ~

- about 3 wks from egg to adult.
- adults can live up to 2 wks.
- 5 wk treatment interval for designing insecticide rotations

PEST COMPLEX ATTACKING FLORIDA TOMATO



	Vegetative	Flowering	Green Fruit	Ripe Fruit
Whiteflies				
Mites				
Thrips				
Leafminers				
Caterpillars				

MODE OF ACTION

- Mode of Action: the way an insecticide kills.
- More specifically, the means by which a toxin affects the anatomy, physiology, or biochemistry of an organism.
- Insecticide Resistance Action Committee www.irac-online.org
  - Defines modes of action
  - Provides MoA code to facilitate resistance management
- There are presently 31 main mode of action groups for insecticides.

ACTIVE INGREDIENT

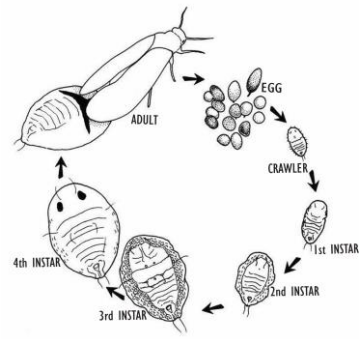
- The component of a pesticide formulation responsible for the toxic effect (Pedigo 4th edition).
- The same active ingredient can be sold under different trade names for the same commodity
  - For example, abamectin is a miticide that is sold under different trade names for managing mites on vegetables (Abacus, Abba, Agri-Mek, and others).
- Companies almost always use a different trade name for the same active ingredient for vegetables vs ornamentals.
  - For example, spirotetramat (MoA 23) is sold as Movento for vegetables and Kontos for ornamentals.
  - When formulated for the certified organic market, a different trade name is often used.
- The biopesticide *Beauveria bassiana* is sold as BotaniGard for conventional use and Mycotrol-O for organic use.

SOME INSECTICIDE GROUPS ACTIVE ON THE NERVOUS SYSTEM

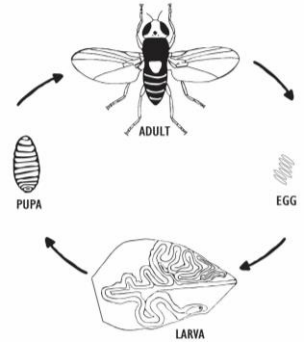
Group	MoA Code	Mode of Action	Examples
Carbamates	1A	Acetylcholinesterase inhibitors	oxamyl, methomyl
Organophosphates	1B	Acetylcholinesterase inhibitors	malathion, acephate, dimethoate
Pyrethroids	3A	Sodium channel modulators	bifenthrin, zeta-cypermethrin, lambda-cyhalothrin
Neonicotinoids	4A	Nicotinic acetylcholine competitive modulators	imidacloprid, dinotefuran, thiamethoxam
Spinosyns	5	Nicotinic acetylcholine allosteric modulators	spinosad, spinetoram

INSECTICIDES THAT PREVENT IMMATURE INSECTS FROM DEVELOPING (GROWTH REGULATORS)

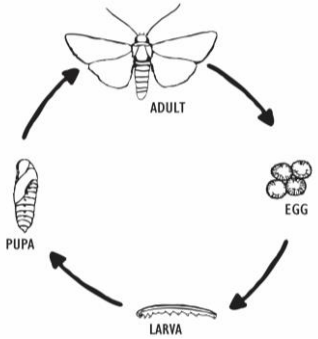
Group	MoA Code	Mode of Action	Examples	Comments
Insect Growth Regulators	7	Juvenile hormone mimics	pyriproxifen	Several orders
	15	Chitin biosynthesis inhibitors O type	novaluron	Several orders
	16	Chitin biosynthesis inhibitors I type	buprofezin	Primarily Homoptera (certain sucking insects)
	17	Molting disruptor, dipteran	cyromazine	Diptera (flies)
	18	Ecdysone receptor agonist	methoxyfenozide, tebufenozide	Lepidoptera (caterpillars)



Whitefly life cycle

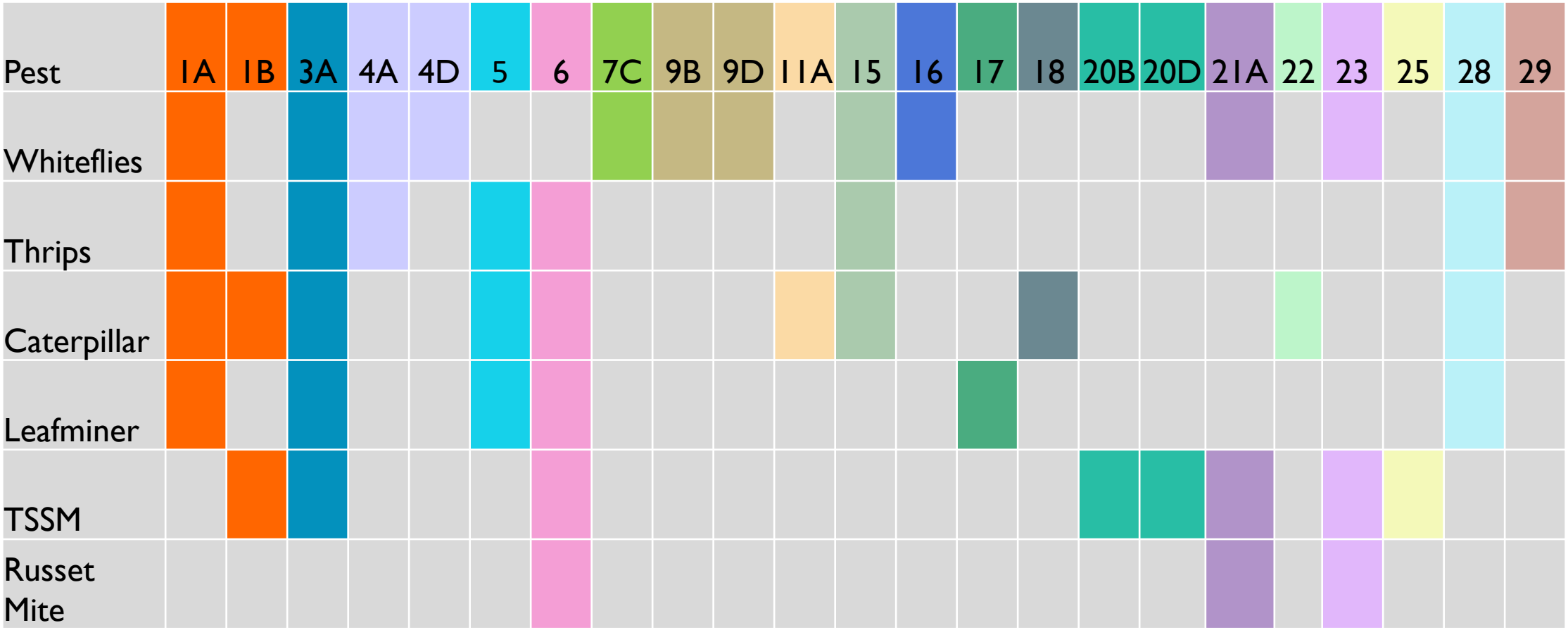


Leafminer life cycle



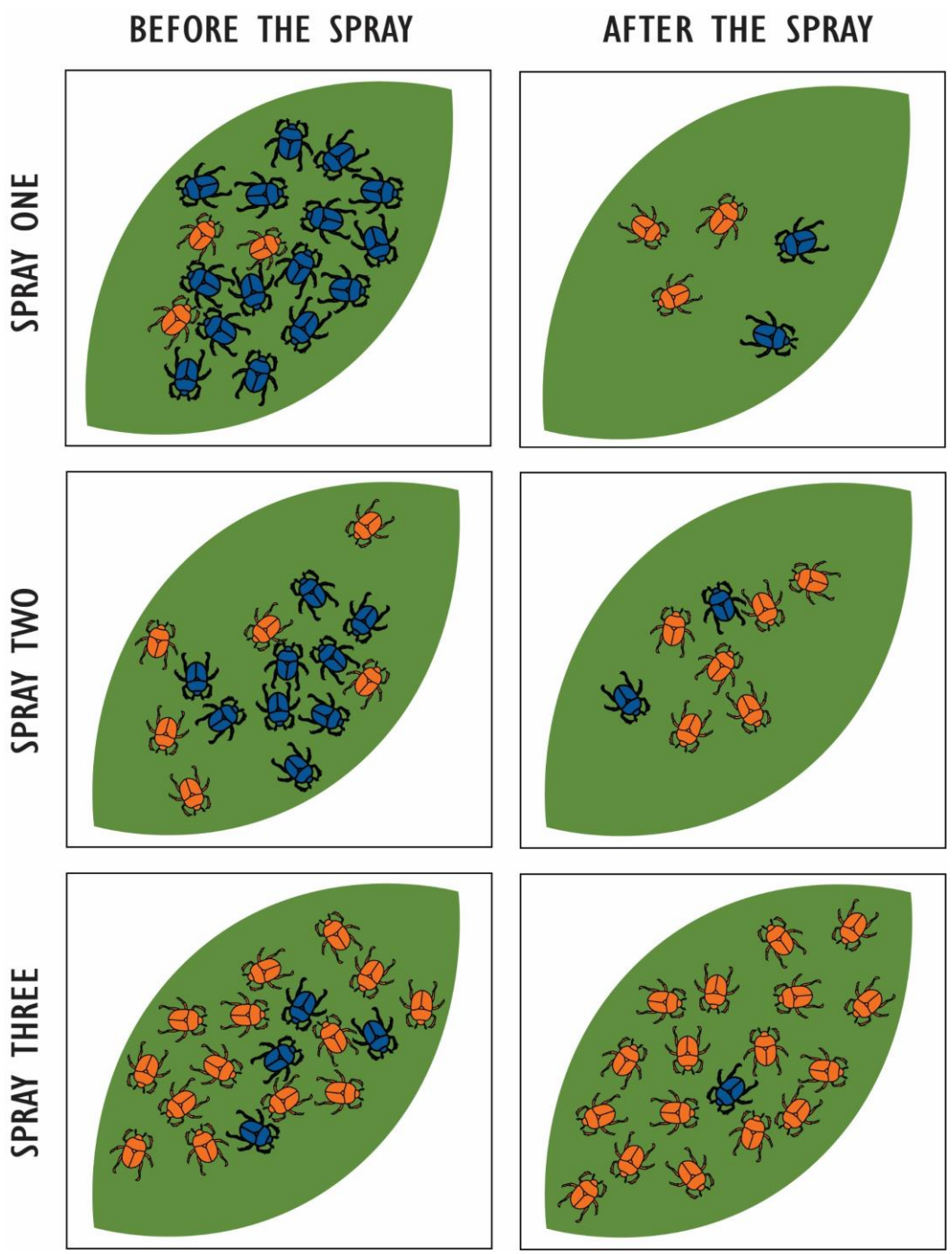
Moth life cycle

MODES OF ACTION REGISTERED FOR USE ON FLORIDA TOMATO FOR ARTHROPOD PESTS



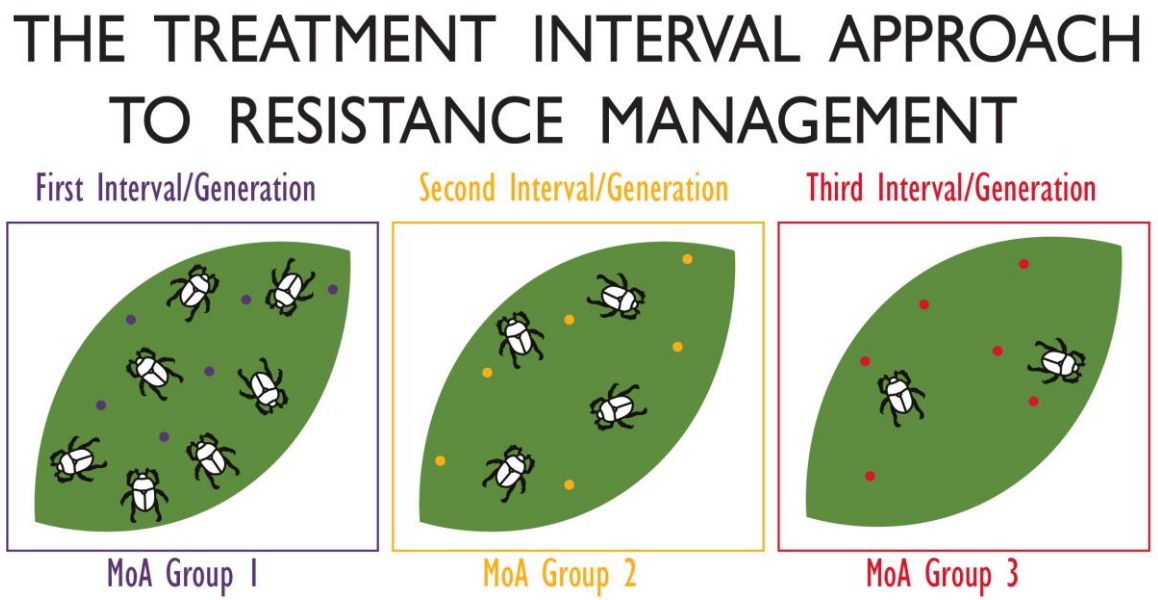
INSECTICIDE RESISTANCE

Insecticide resistance develops when successive generations of the pest are exposed to the same mode of action.



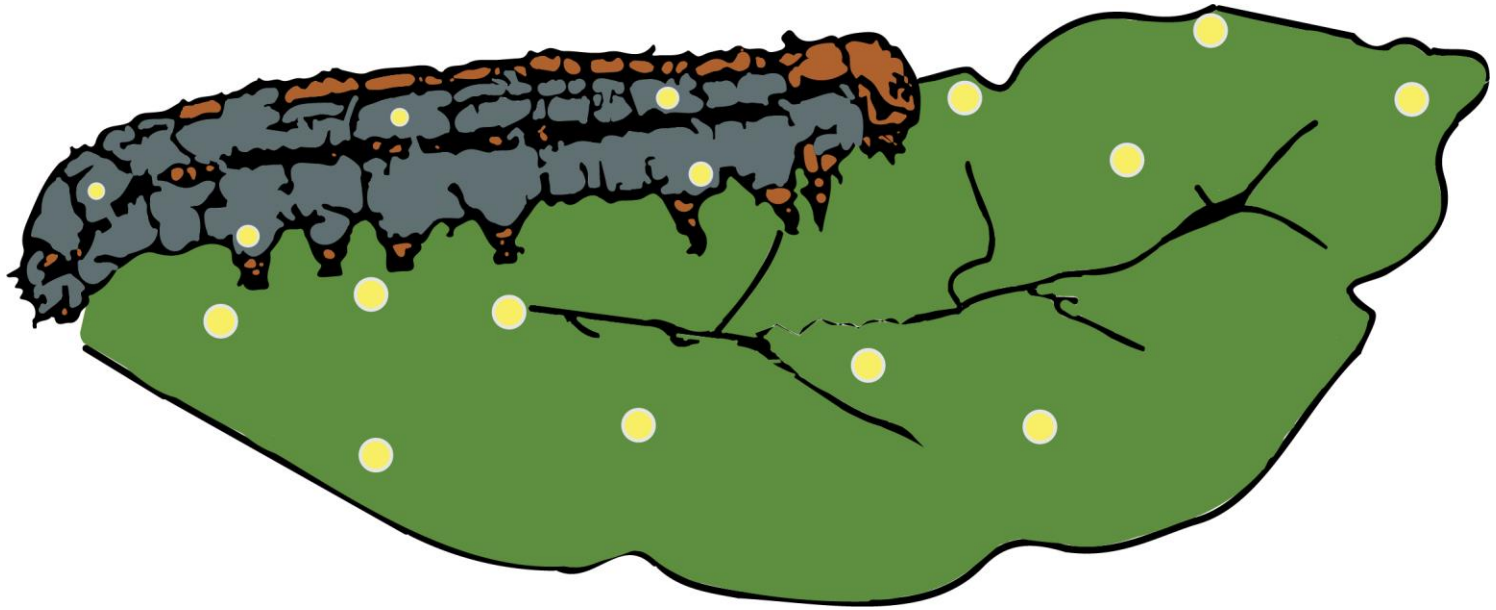
TREATMENT INTERVAL APPROACH

The treatment interval approach is used to avoid treating successive generations of the pest with the same mode(s) of action.



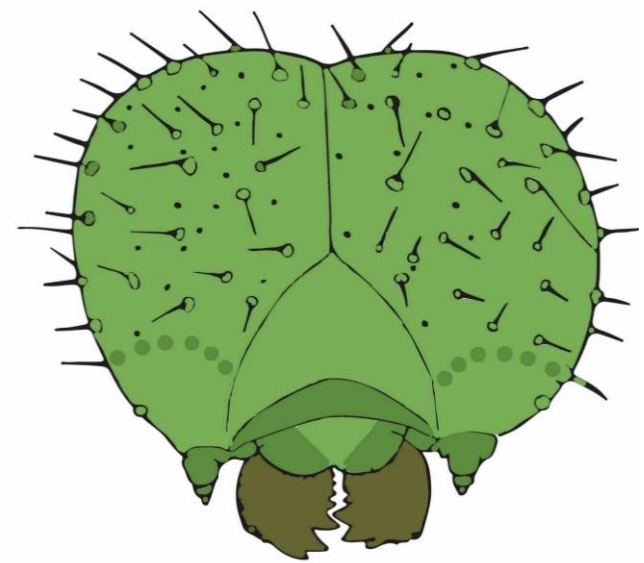
CONTACT INSECTICIDES

- Insecticide enters body when insect is directly sprayed or moves over treated surface
- Insecticide absorbed through body wall.

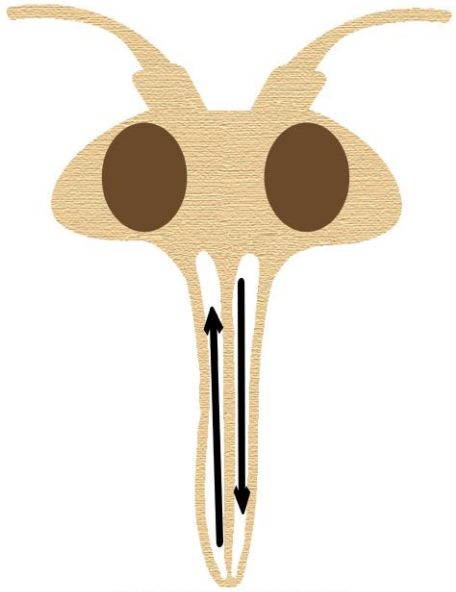


INGESTION

- Insect consumes treated plant tissue (chewing mouthparts) or ingests plant sap from vascular system (piercing-sucking mouthparts).



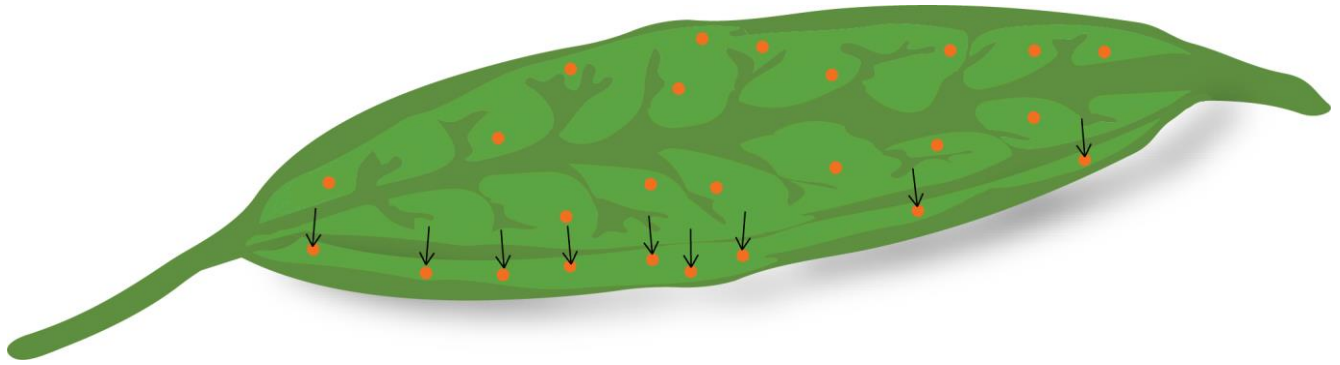
CHEWING



PIERCING-SUCKING

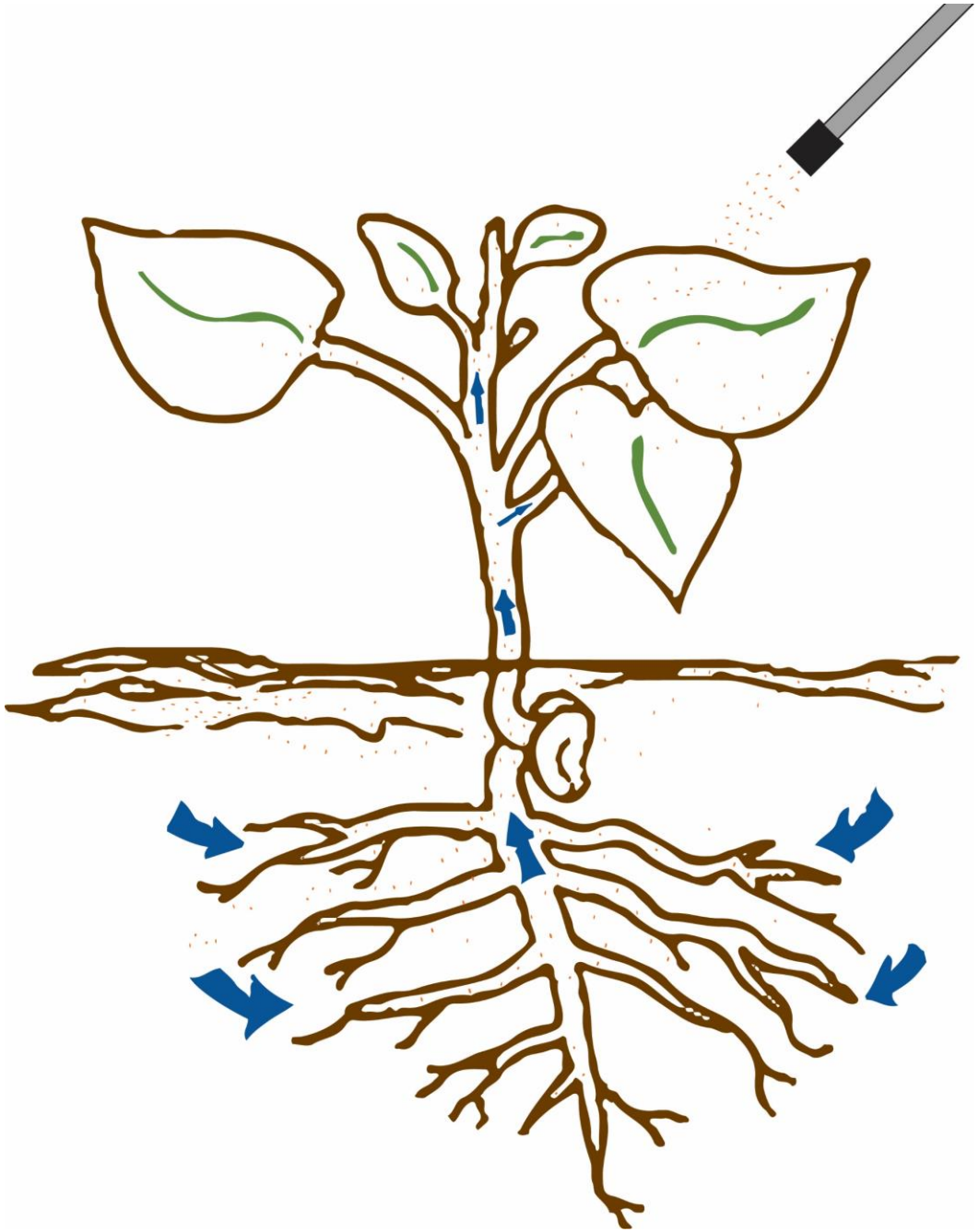
TRANSLAMINAR INSECTICIDES

- Move from one side of leaf to other
- Reservoir of insecticide is maintained in leaf
- Common examples: abamectin, acephate, spinetoram



SYSTEMIC INSECTICIDES

- Taken up by roots or foliage
- Move through plant's vascular system
- Mostly used against insects with piercing-sucking mouthparts
- Common examples: neonicotinoid and diamide insecticides



BIOPESTICIDES

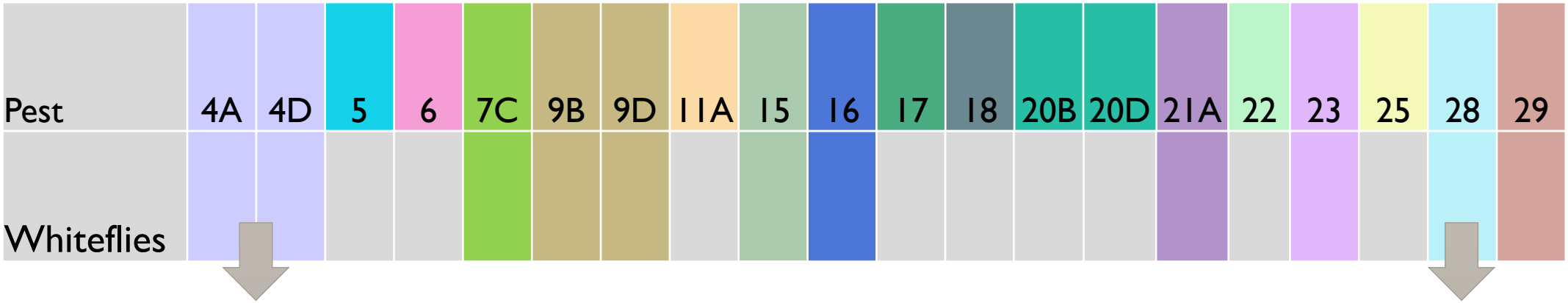
Most biopesticides:

- Low risk for resistance (most have no IRAC MoA)
- Pollinator compatible
- Biocontrol compatible
- Have 4 hour REI
- Have 0 day PHI
- Are approved for certified organic production

BIOPESTICIDES

Type	Group	MoA Code	Examples (Trade Name)	Mode of Action	Comments
Bacillus thuringiensis products	Bts	11A	Dipel, Javelin, Xentari	Microbial disruptors of insect midgut membranes	Mostly caterpillars
Mechanical effect	Insecticidal soaps and oils	----	M-Pede, Suffoil-X, JM Stylet Oil	Suffocation, desiccation, incapacitation	Small soft bodied insects
Microbial	Entomo-pathogens	----	BotaniGard, Mycotrol, PFR-97	Fungal infection	Require high humidity
Botanical and fermentation products	Azadirachtin products, others	----	Aza-Direct, Grandevo	Repellant, IGR	

MODES OF ACTION REGISTERED FOR MANAGEMENT OF WHITEFLIES AND TYLCV ON FLORIDA TOMATO



Neonicotinoids/butenolide:

- Systemic –
- Reduce virus transmission

Diamide (cyantraniliprole):

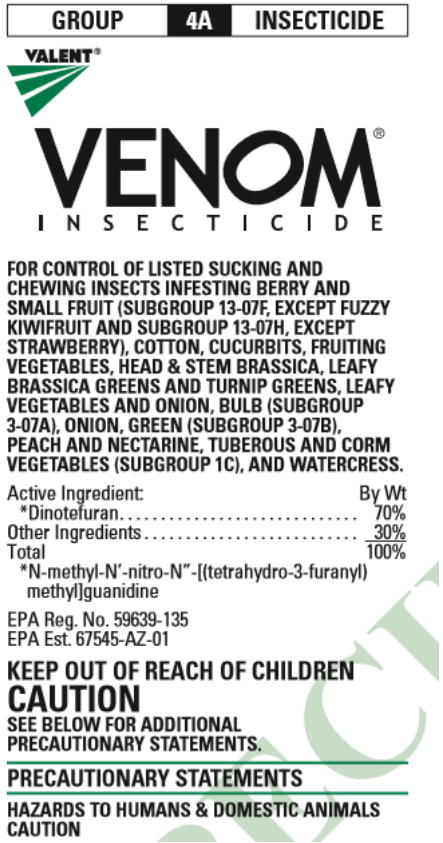
- Systemic –
- Reduces virus transmission

Also effective against leafminers and caterpillars.

Modes of action are grouped by number (main group), not letter (subgroup) in treatment intervals.

Dinotefuran (Venom) – MoA Group 4A (neonicotinoid). Extensive pollinator protection language
Flupyradifurone (Sivanto Prime) – MoA Group 4D (butenolide). Pollinator Best Management Practice Language

In some instances insects may be resistant to active ingredients in one subgroup, but not the other.



GROUP 4A INSECTICIDE

VALENT®

VENOM®

INSECTICIDE

FOR CONTROL OF LISTED SUCKING AND CHEWING INSECTS INFESTING BERRY AND SMALL FRUIT (SUBGROUP 13-07F, EXCEPT FUZZY KIWIFRUIT AND SUBGROUP 13-07H, EXCEPT STRAWBERRY), COTTON, CUCURBITS, FRUITING VEGETABLES, HEAD & STEM BRASSICA, LEAFY BRASSICA GREENS AND TURNIP GREENS, LEAFY VEGETABLES AND ONION, BULB (SUBGROUP 3-07A), ONION, GREEN (SUBGROUP 3-07B), PEACH AND NECTARINE, TUBEROUS AND CORM VEGETABLES (SUBGROUP 1C), AND WATERCRESS.

Active Ingredient:	By Wt
*Dinotefuran	70%
Other Ingredients	30%
Total	100%

*N-methyl-N′-nitro-N″-[(tetrahydro-3-furanyl) methyl]guanidine

EPA Reg. No. 59639-135
EPA Est. 67545-AZ-01

KEEP OUT OF REACH OF CHILDREN
CAUTION
SEE BELOW FOR ADDITIONAL PRECAUTIONARY STATEMENTS.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS & DOMESTIC ANIMALS
CAUTION

BAYER

SIVANTO™ prime

Net Contents:
1 Gallon

FLUPYRADIFURONE GROUP 4D INSECTICIDE

For use in pest management and suppression of listed insects which vector diseases.

ACTIVE INGREDIENT: Flupyradifurone* 17.09%
OTHER INGREDIENTS: 82.91%
TOTAL: 100.00%

Contains 1.67 pounds active ingredient per U.S. gallon (200 grams AI/liter)
*CAS No. 951659-40-8

EPA Reg. No. 264-1141

KEEP OUT OF REACH OF CHILDREN
CAUTION

For MEDICAL and TRANSPORTATION Emergencies ONLY Call 24 Hours a Day 1-800-334-7577
For PRODUCT USE Information Call 1-866-99BAYER (1-866-992-2937)

Please refer to booklet for additional precautionary statements and directions for use.

Produced for:
Bayer CropScience LP
P.O. Box 12014, 2 T.W. Alexander Drive
Research Triangle Park, North Carolina 27709
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US61381668B 180216B 02/18

Group 28: diamides are systemic insecticides that target whiteflies, caterpillars and leafminers on tomato.

CORAGEN®
INSECT CONTROL

WITH THE ACTIVE INGREDIENT RYNAXYPYR® | GROUP 28 INSECTICIDE

CORAGEN® is a suspension concentrate.

Contains 1.67 lb. active ingredient per gallon.

Active Ingredient	*By Weight*
Chlorantraniliprole 3-Bromo-N-[4-chloro-2-methyl-6-[(methylamino)carbonyl]phenyl]-1-(3-chloro-2-pyridinyl)-1H-pyrazole-5-carboxamide	18.4%
Other Ingredients	81.6%
TOTAL	100.0%

EPA Reg. No. 279-9606 EPA Est. No. 352-GA-001

Nonrefillable Container
Net: 1 Quart
OR
Refillable Container
Net: _____

Coragen (chlorantraniliprole) is effective against caterpillars and leafminers, and suppresses whitefly nymphs on tomato.

VERIMARK®
INSECT CONTROL

WITH THE ACTIVE INGREDIENT CYAZYPYR® | GROUP 28 INSECTICIDE

For soil applications to brassica, bulb, cucurbit, fruiting, leafy, legume (except soybeans), root and tuberous and corm vegetables; citrus trees, peanuts and tobacco for pest management of sucking and chewing insects that can vector certain plant diseases, aiding in optimization of the crop's potential.

Active Ingredient	*By Weight*
Cyantraniliprole 3-bromo-1-(3-chloro-2-pyridinyl)-N-[4-cyano-2-methyl-6-[(methylamino)carbonyl]phenyl]-1H-pyrazole-5-carboxamide	18.66%
Other Ingredients	81.34%
TOTAL	100.0%

VERIMARK® is a suspension concentrate. SHAKE WELL BEFORE USING.

Contains 1.67 lb. active ingredient per gallon.

EPA Reg. No. 279-9616 EPA Est. No. 352-GA-001

Nonrefillable Container Net: Weight 80 oz *OR* **Refillable Container** Net: _____

EXIREL®
INSECT CONTROL

WITH THE ACTIVE INGREDIENT CYAZYPYR® | GROUP 28 INSECTICIDE

For foliar applications to brassica, bulb, cucurbit, fruiting, leafy, legume (except soybeans), root and tuberous and corm vegetables; commercially grown greenhouse cucumber, eggplant, pepper and tomato; cotton, oil seed crops; strawberries; bushberries; peanuts; citrus, pome, and stone fruits; tree nuts; and tobacco for pest management of sucking and chewing insects that can vector certain plant diseases, aiding in optimization of the crop's potential.

Active Ingredient	*By Weight*
Cyantraniliprole 3-bromo-1-(3-chloro-2-pyridinyl)-N-[4-cyano-2-methyl-6-[(methylamino)carbonyl]phenyl]-1H-pyrazole-5-carboxamide	10.20%
Other Ingredients	89.80%
TOTAL	100.00%

EXIREL® is a suspoemulsion (oil in water emulsion). SHAKE WELL BEFORE USING.

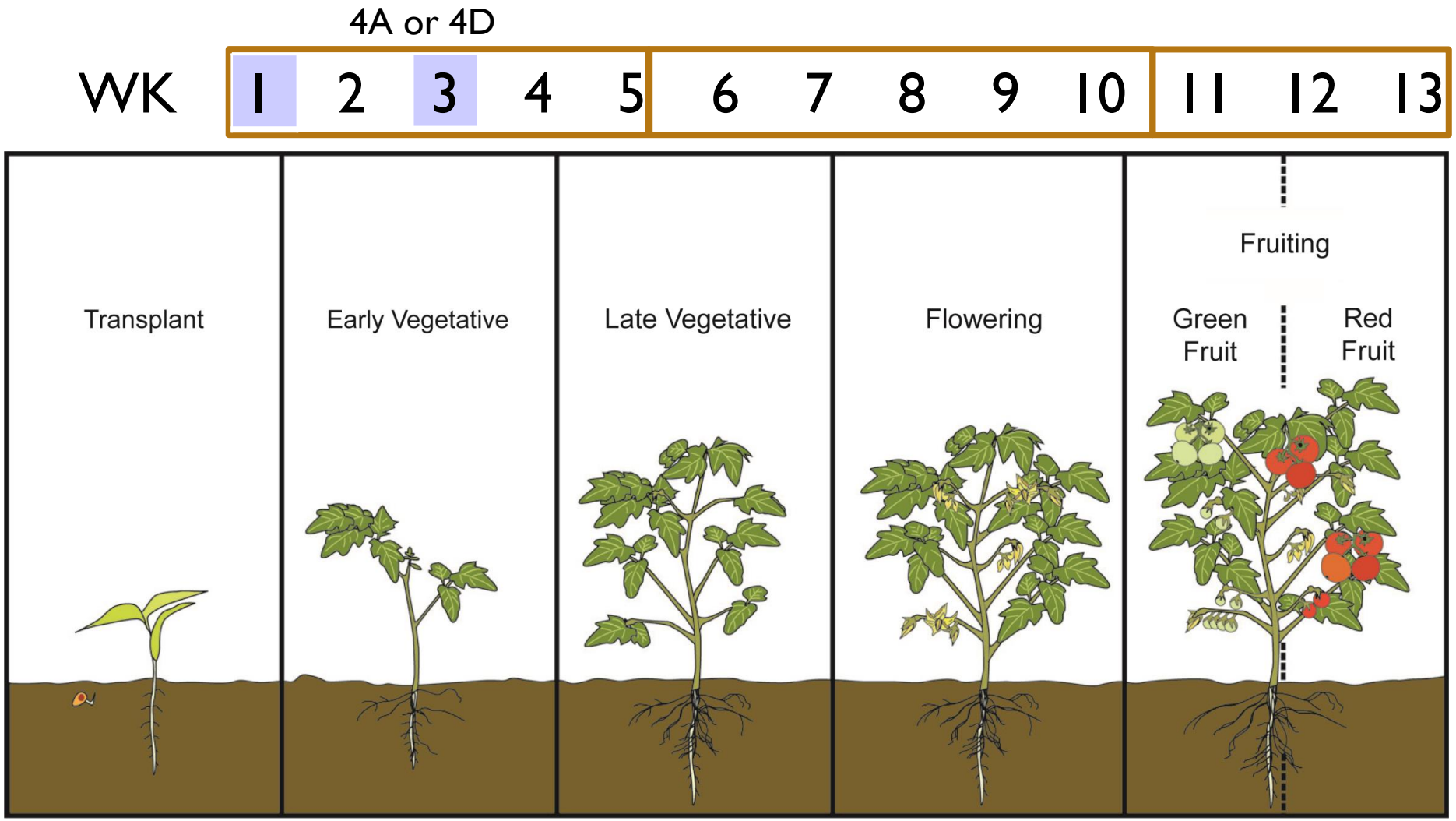
Contains 0.83 lb. active ingredient per gallon.

EPA Reg. No. 279-9615 EPA Est. No. 352-GA-001

Nonrefillable Container Net: Contents 1 Gallon *OR* **Refillable Container** Net: _____

Verimark and Exirel (cyantraniliprole) are effective against whitefly adults and nymphs, as well as caterpillars and leafminers on tomato. Cyantraniliprole has been implicated in the reduction of transmission of *Tomato yellow leaf curl virus* by whiteflies.

A FIVE-WEEK TREATMENT INTERVAL IS USED TO DESIGN INSECTICIDE ROTATIONS FOR WHITEFLY



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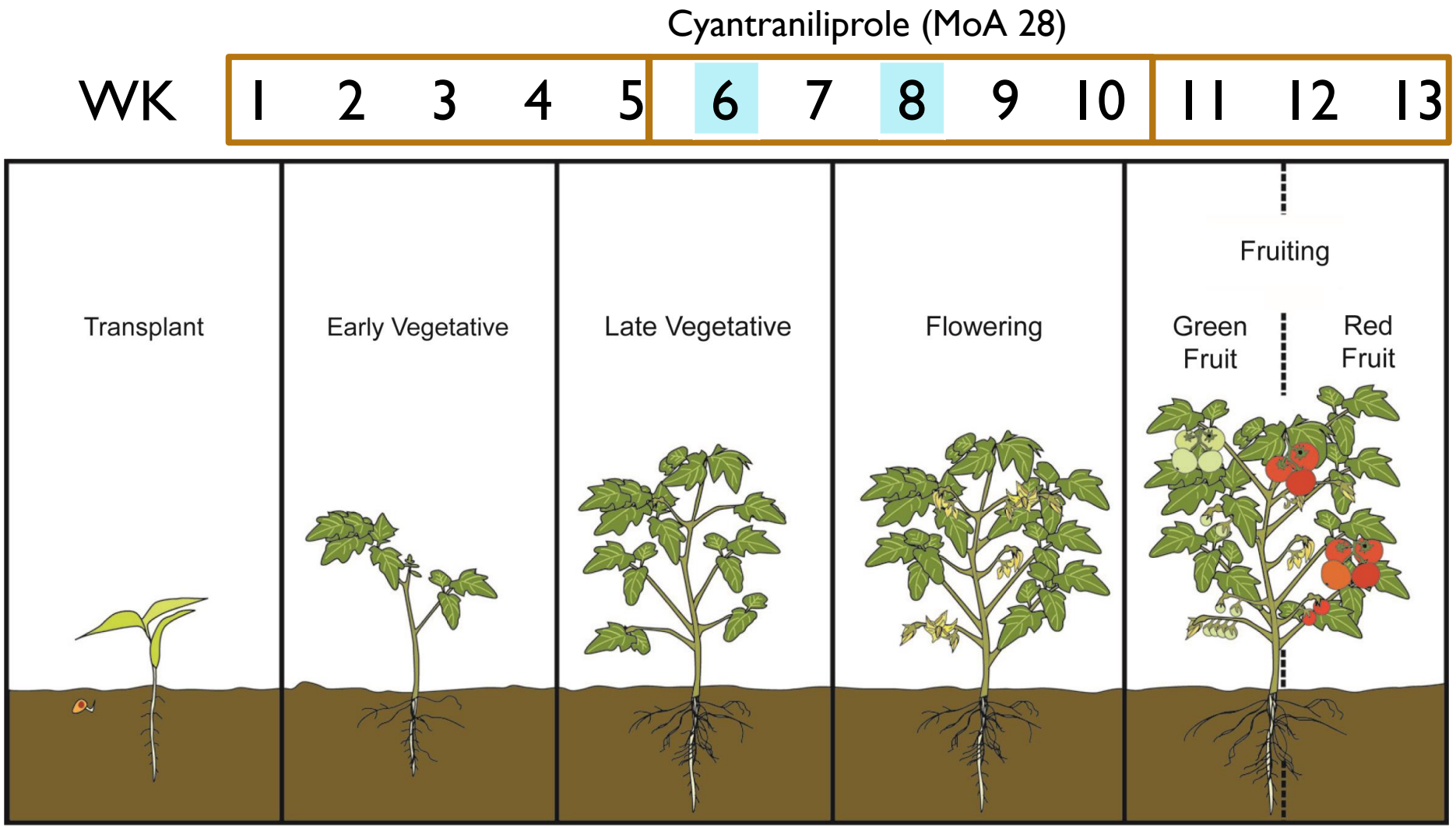

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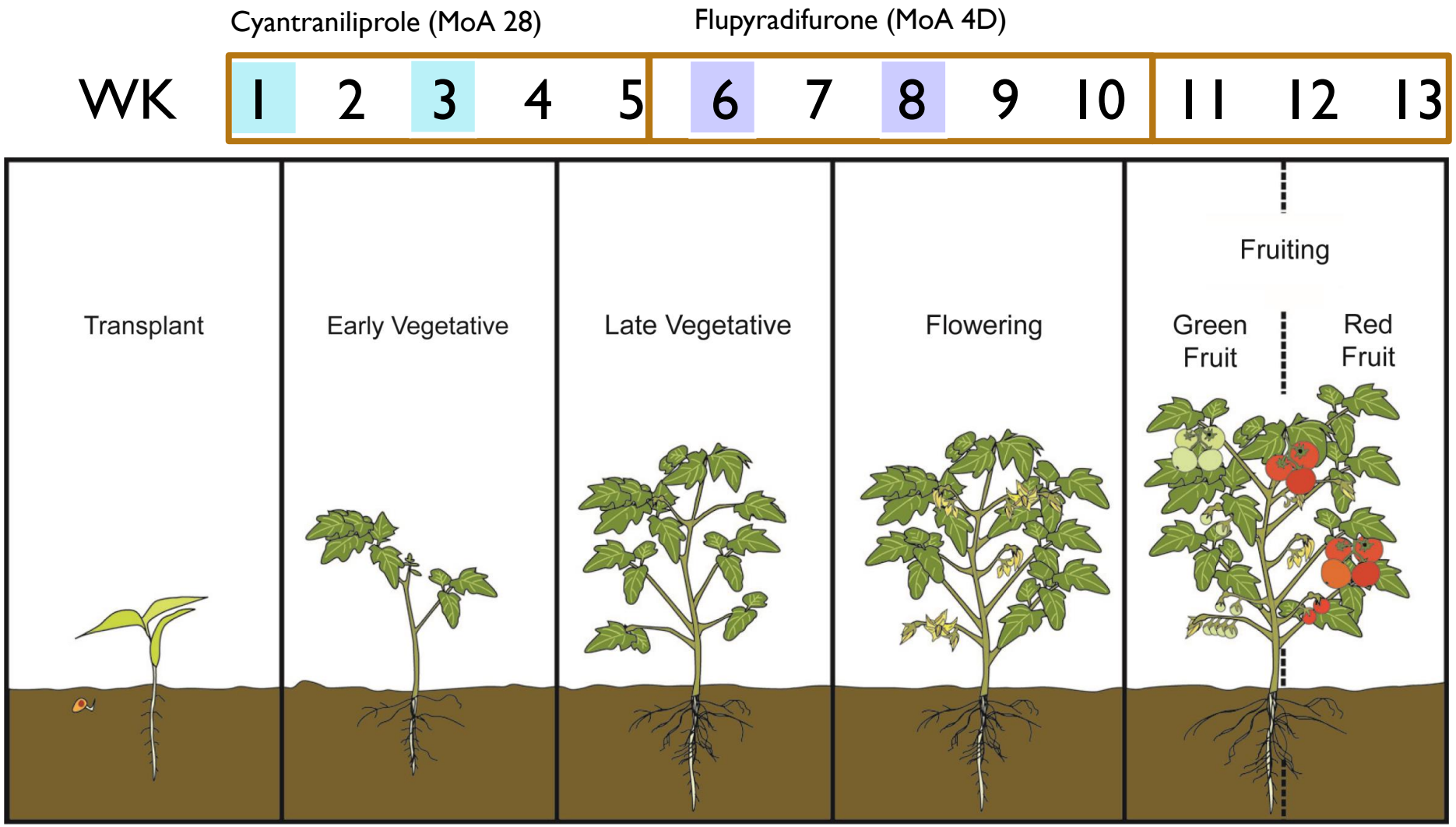
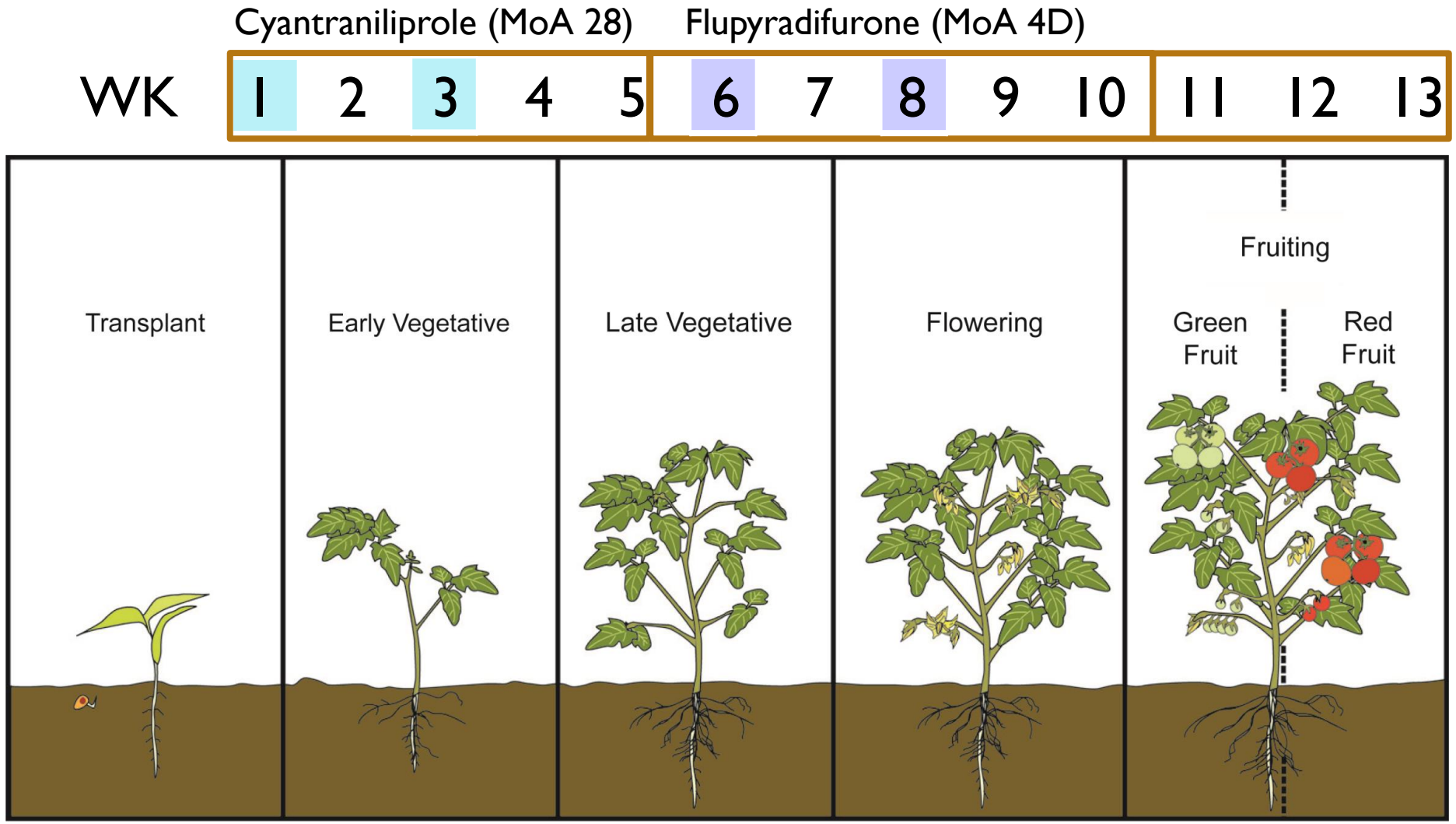
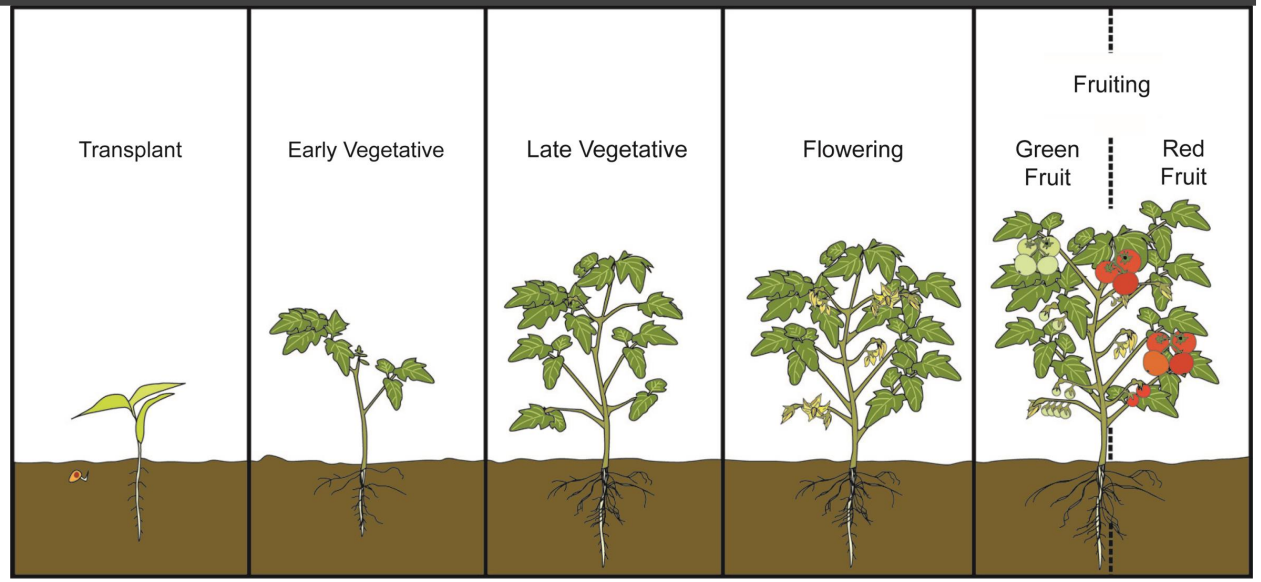


In this scenario a grower should not apply chlorantraniliprole (Coragen, MoA 28) during the second five-week treatment interval for caterpillars or leafminers because a group 28 (cyantraniliprole) has been applied during the first five-week treatment interval. The grower would need to choose different modes of action for caterpillars (for example 11A, 18, 22A) or leafminers (for example 6, 17).



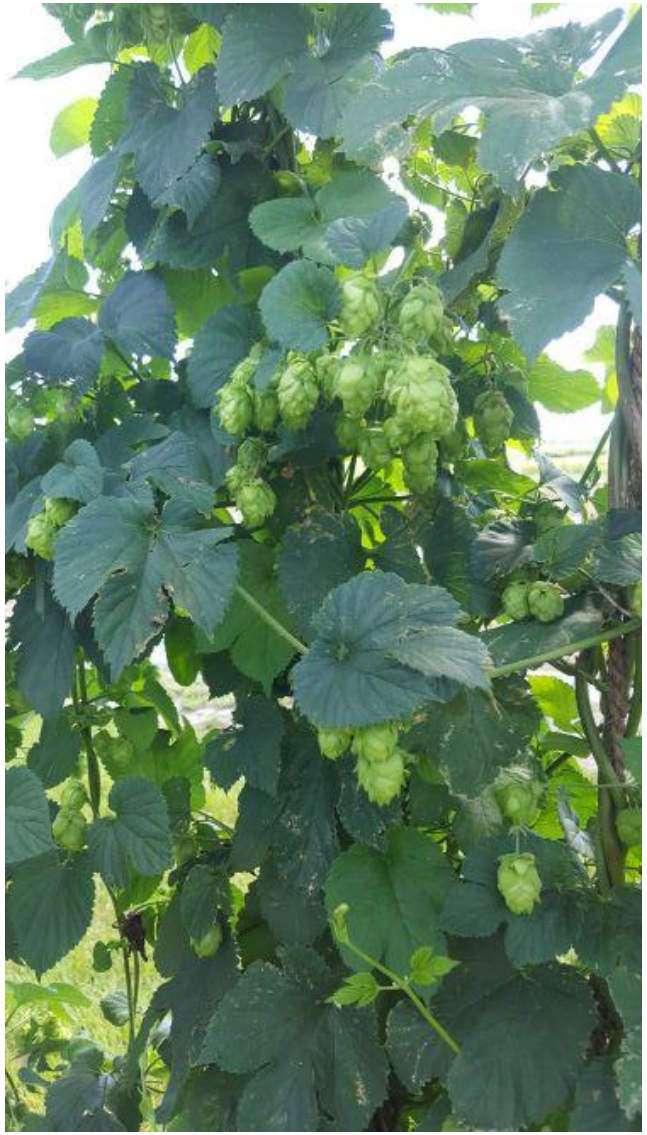
PEST COMPLEX ATTACKING FLORIDA TOMATO



	Vegetative	Flowering	Green Fruit	Ripe Fruit
Whiteflies				
Mites				
Thrips				
Leafminers				
Caterpillars				

2.5 Acre Hop Yard, GCREC

Hops cones = fruiting bodies/strobiles.
Contain lupulins: hops acids and essential oils.



At GCREC, hops are grown Feb-June.

Early Vegetative Late Vegetative Cone Formation Harvest

https://rfclipart.com/beer-hop-cone-and-leaf-1964-vector-clipart.html

- Scouting the upper stratum of hops is a challenge.

- Shorter trellised hops are easier to scout.

Primary pests:
damage cone

Secondary pests:
damage foliage, stem

Tetranychus spp. on hops, GCREC

Two-spotted spider mites

- Life cycle: 8-12 days at 86 F.

- Females produce 5-6 eggs per day, 60-120 in lifetime.

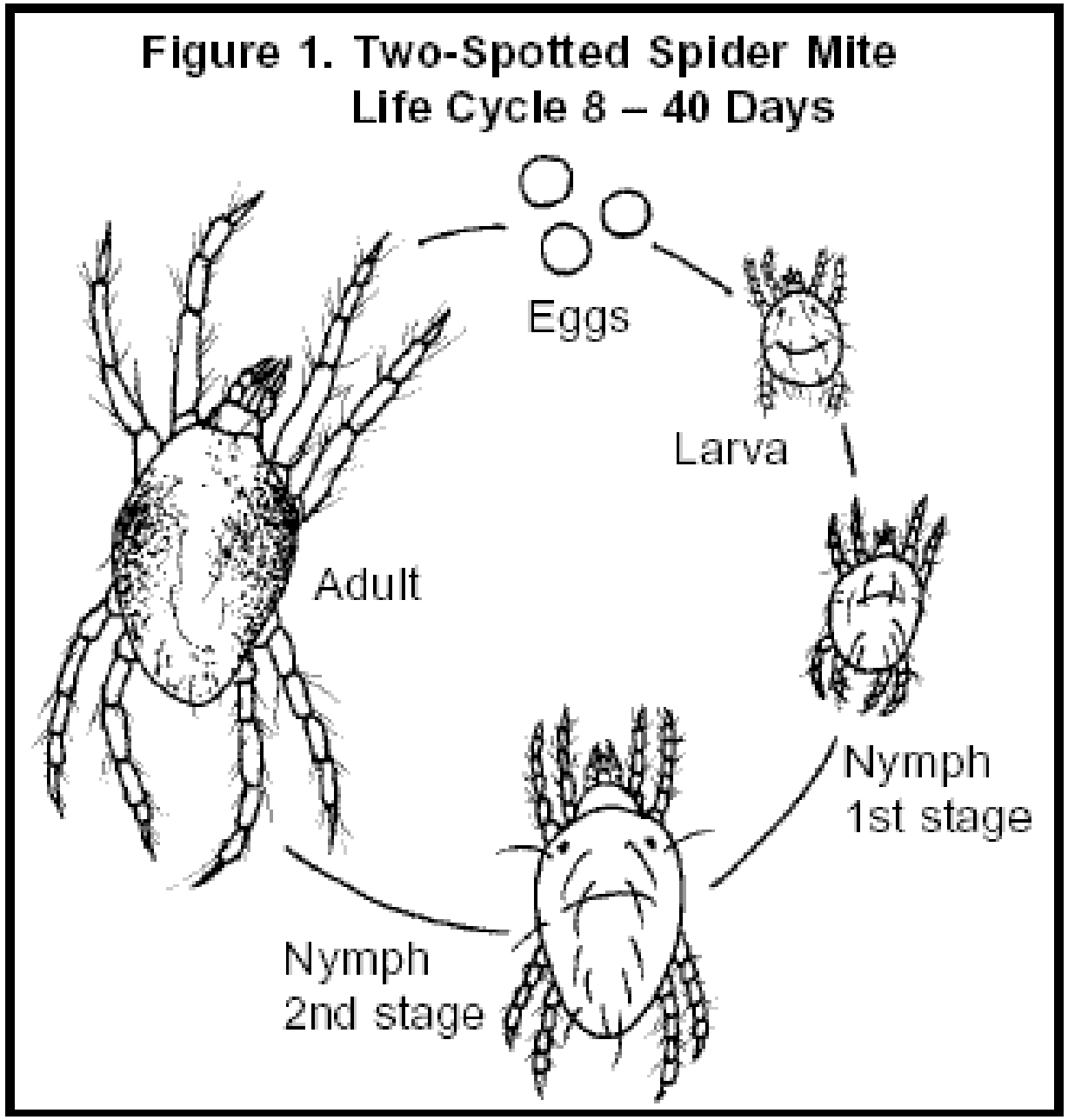


Image: Koppert

Active Ingredient (# applications)	Mode of Action Number	Examples	Restricted	PHI (days)
abamectin	6	Agri_mek SC	Yes	28
hexythiazox (1)	10A	Savey 50 DF	No	Apply up to burr formation
etoxazole (1)	10B	Zeal	No	7
acequinocyl (2)	20B	Kanemite 15 SC	No	7
bifenazate (1)	20D	Acramite 50 WS	No	14
fenazaquin (1)	21A	Magister SC	No	
fenpyroximate (1)	21A	Portal XLO	No	15
spiridiclofen (1)	23	Envidor	No	14
spirotetramat	23	Movento	No	7

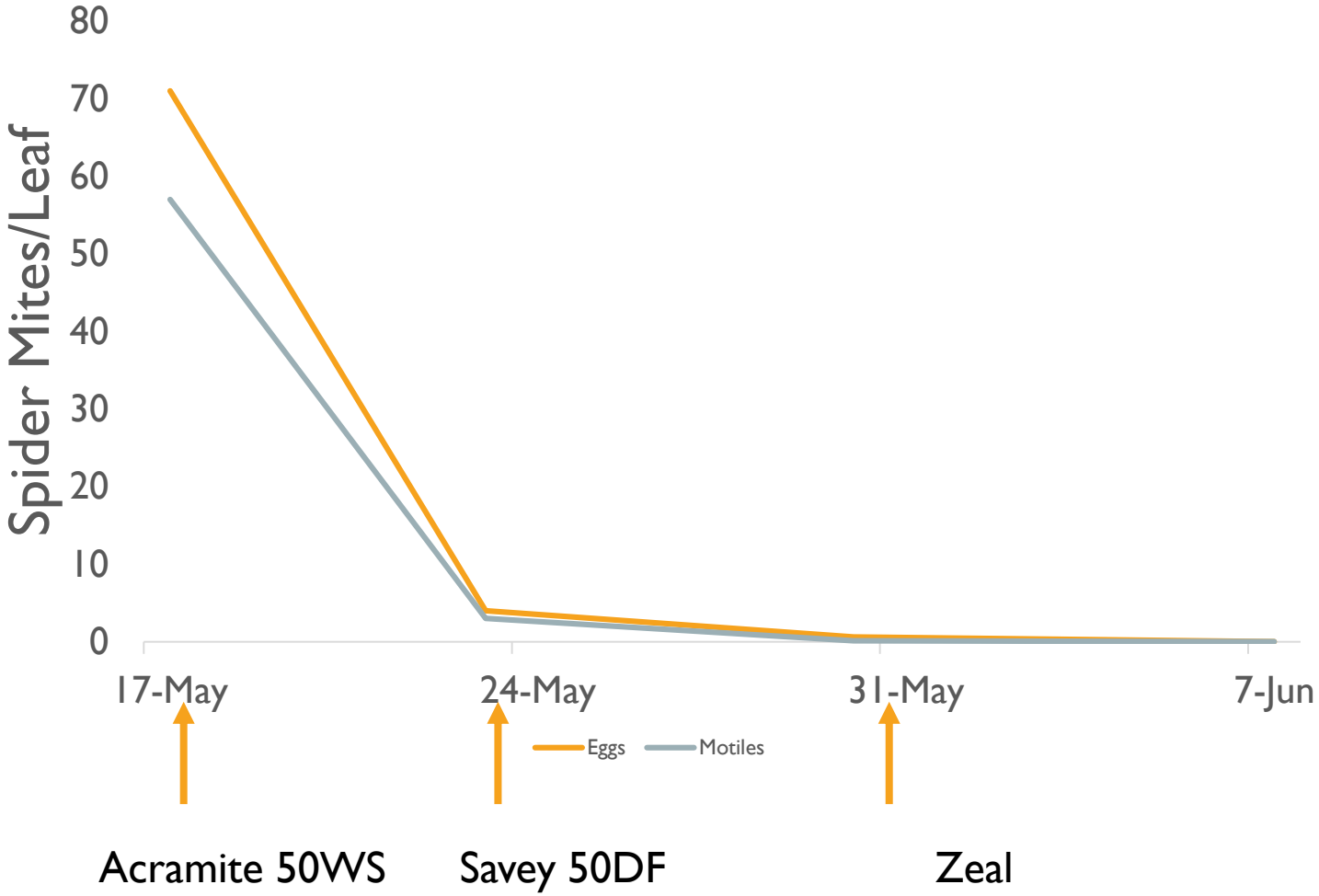
Miticides registered for use on hops.

Oberon (spiromesifen MoA 23) and Nealta (cyflumetofen MoA 25) not registered.

Biopesticides (mostly OMRI approved)

- Insecticidal soap
- Azadirachtin products
- Neem oil
- Pyrethrins
- Microbial controls: *Beauvaria bassiana, Paecilomyces fumosoroseus*
- **Sulfur**

Two-Spotted Spidermite Spray Program Foe Farm Brooksville Spring 2018



Applying miticides GCREC hopyard

Spray card evaluation

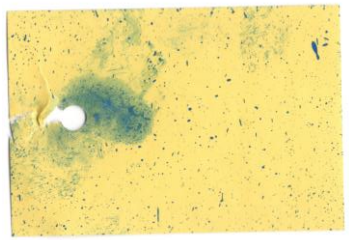
- Cards placed every 32 ft along row at 3 heights:

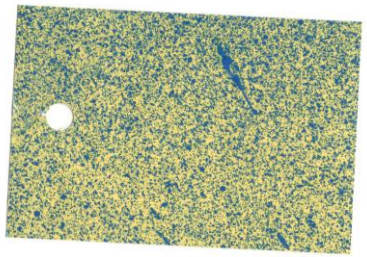
- 3, 9 and 18 ft off the ground

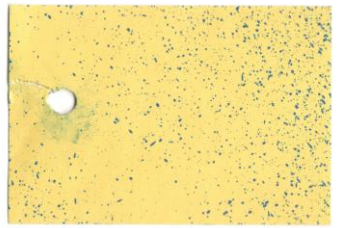
18 ft

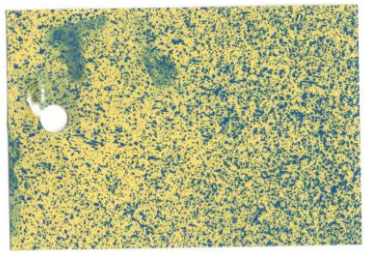
9 ft

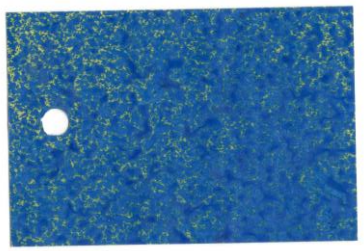
3 ft

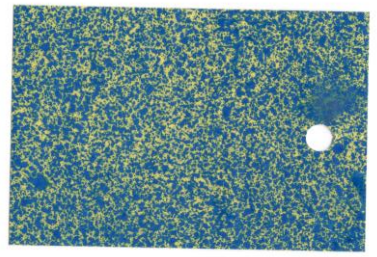


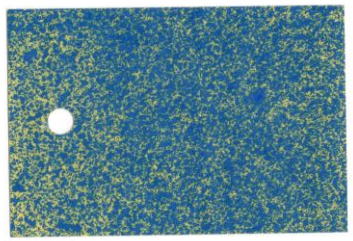


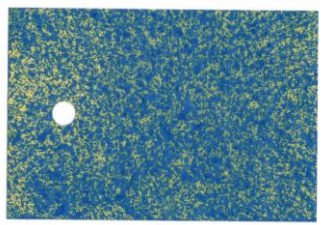


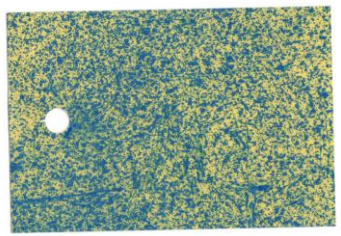








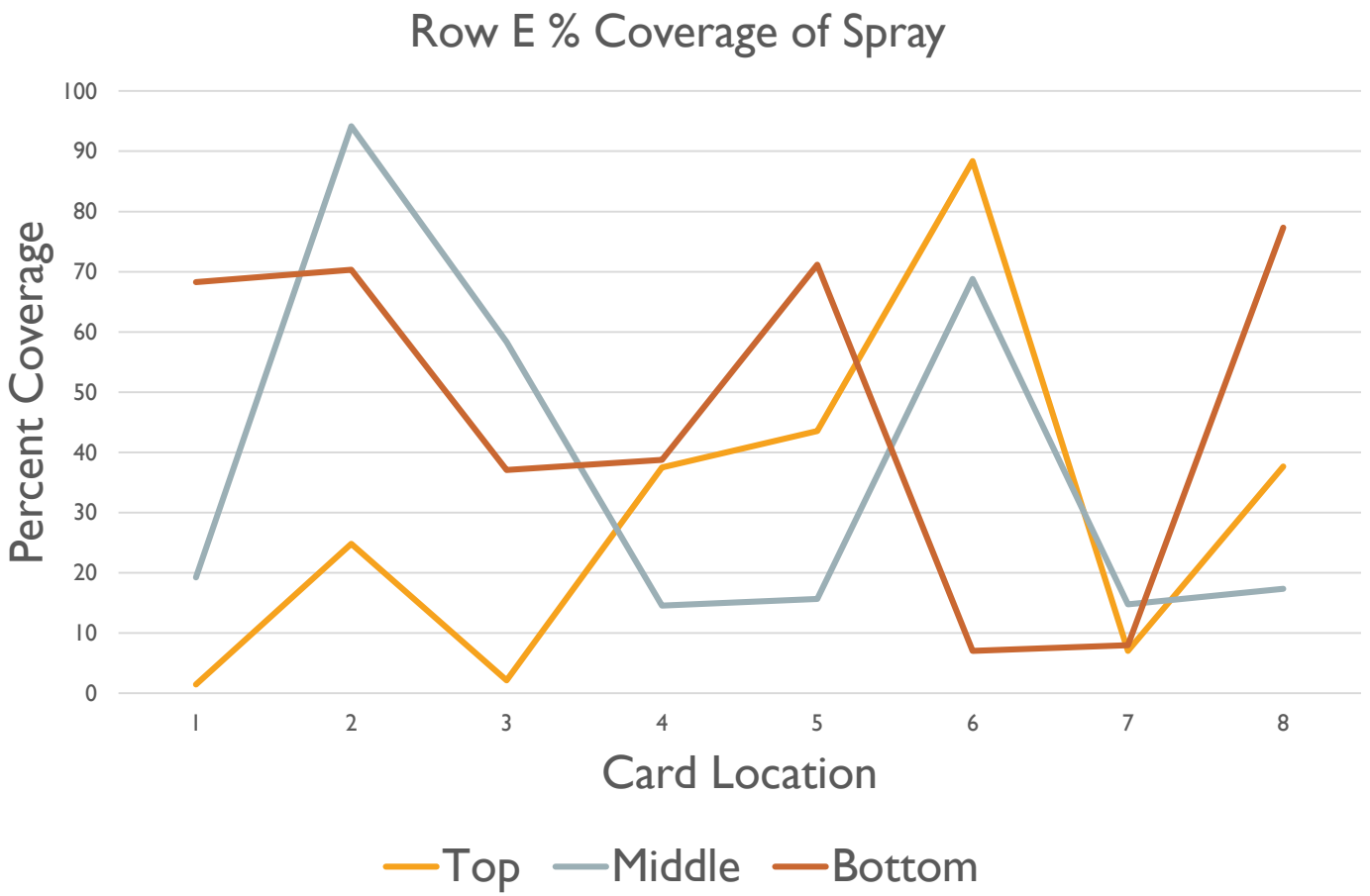




1 ft

32 ft

64 ft


Row E % Coverage of Spray
Percent Coverage
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
Card Location
Top
Middle
Bottom

Spider Mites vs Predatory Mites

TSSM and predatory mite (*Amblyseius californicus*)

Phytoseiulus persimilis

Photos: Lyle Buss

GCREC Hopyard Spring 2019

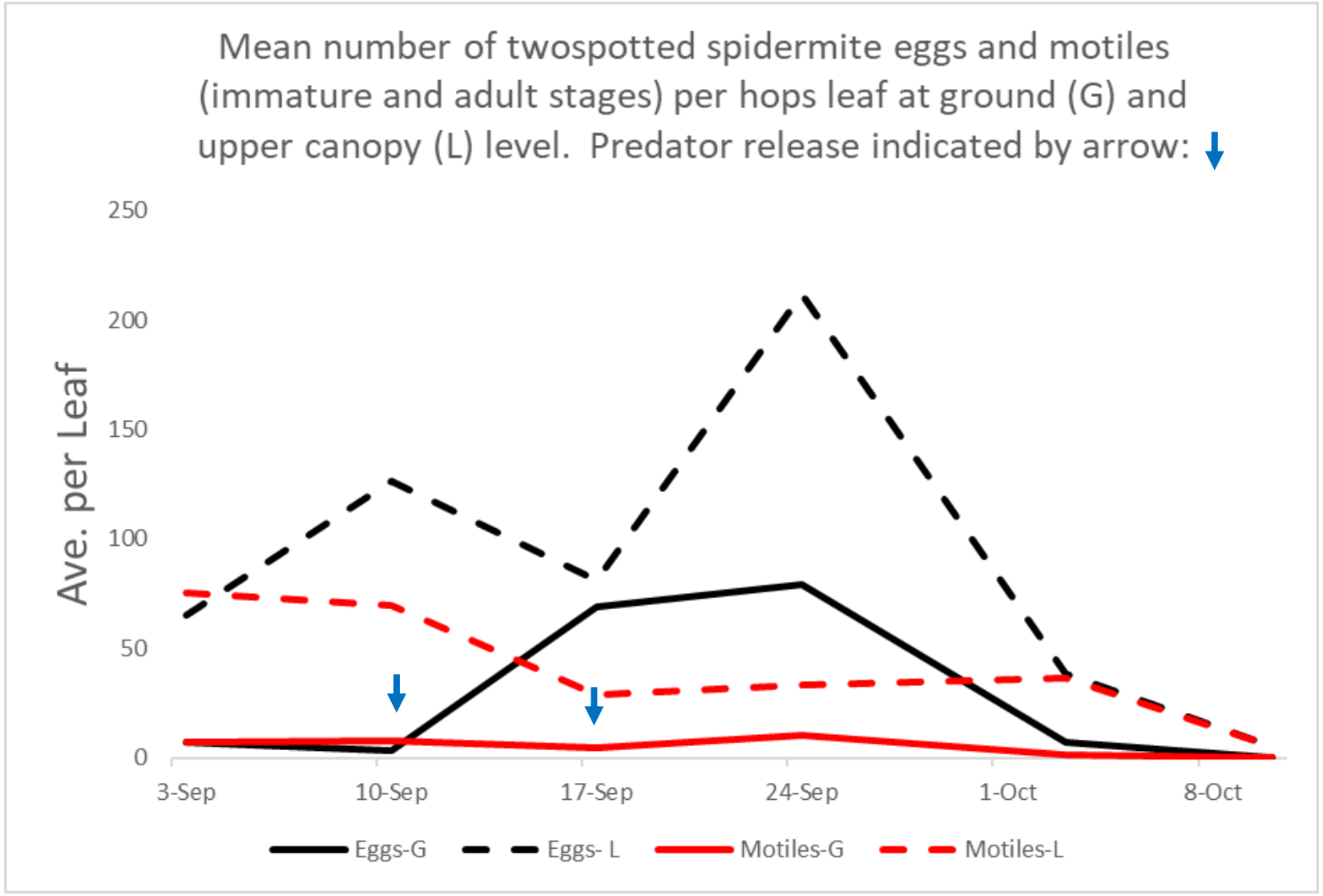
27 March ~ 10 persimilis
every other plant

24 April – same

Donated by BioBee

2019 Fall Hops Season Spider Mite Densities.

Phytoseiulus persimilis released Sept 10 and 17; 15 *persimilis* per plant total.



2019 Fall. *Neoseiulus* sp. predatory mites (naturally occurring) found with spider mite infestations

Stethorus (Coccinelidae): naturally occurring mite predator

DESIGNING INSECTICIDE ROTATIONS

- Group modes of action by treatment interval, defined by life cycle of pest
- Carbamate (1A), organophosphate (1B) and pyrethroid (3A) insecticides are rarely the go-to products for any pest problem in vegetables
- Systemic insecticides are important for management of vectored pathogens
- Insecticides that target multiple pest groups should be saved for when those pests are likely to be present
- Impacts on pollinators and preharvest interval should be taken into account when planning a season-long insecticide program.

INSECTICIDES WITHIN THE CONTEXT OF IPM

- Use scouting and threshold information if available
- Deploy other strategies to manage pests and reduce reliance on insecticides (repellent mulches, host plant resistance)
- For efficacy information: Arthropod Management Tests, other peer-reviewed and university-based information online; consult Extension specialists, growers
- Remember there is no 'one size fits all' approach to planning insecticide rotations

SOME THINGS TO ASK BEFORE YOU SPRAY

1. What is the stage of the crop?
2. What has already been sprayed?
3. Are pollinators at risk?
4. How close are you to harvest?
5. Are there older or younger plantings nearby?

THINGS THAT CAN GO WRONG

- Calibration
- Nozzle condition
- Gallonage water per acre
- Adjuvants

UF/IFAS INFORMATION SOURCES FOR UNDERSTANDING PESTICIDE USE

UF/IFAS Pesticide Information Office

- https://pested.ifas.ufl.edu/
- 352-392-4721